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> The invention of the mechanical clock was one of a number of major advances that turned Europe from a weak, peripheral, highly vulnerable outpost of Mediterranean civilization into a hegemonic aggressor. Time measurement was at once a sign of new-found creativity and an agent and catalyst in the use of knowledge for wealth and power. (Davis S. Landes, *Revolution in Time*, Harvard University Press, 1983, p. 12.)

This knowledge came from measurement and reckoning, and it still does. Scientists develop the knowledge, engineers apply it. What has changed is knowledge about how to measure and reckon. Until less than 50 years ago, the slide rule was to the engineer what the stethoscope is to the doctor.

Accounting

Scientists and engineers do not directly produce wealth and power in society. They merely provide the means for some of society to accumulate property through management and trade. The owners also use numbers, but not in the same way scientists and engineers do.

Property comes in a variety of forms, and the numbers used in its management—counts, dates, and prices—cling to names identifying and describing the property. Early forms of accounting 10 millennia ago in southwest Asia used clay tokens whose shape identified the property and whose number denoted the quantity (www.utexas.edu/cola/centers/lrc/numerals/dsb/dsb1.html). Later, these tokens were embedded in clay bullae that served as delivery dockets, and later still tokens were pressed into the surface of a bulla before baking so that its content could be known without breaking it open (Steven Roger Fischer, *A History of Writing*, Reaktion Books, 2001). It would seem likely that, starting around five millennia ago, this led to the cuneiform tablets used primarily for accounting.

Although many cultures developed other forms of recording in accounts and dockets, double-entry bookkeeping provided a significant formalization. Started in Italy around the 15th century, it provided a simple means of validating accounts. The arithmetic was troublesome for accountants, not because it was complex—rarely extending beyond addition and subtraction—but because many numbers were involved. The owners themselves usually employed clerks to do the transcription and arithmetic.

The more direct use of writing for social control is arguably why its technology advanced sooner and faster.

A century ago, governments and businesses adopted punched cards for recording census and accounting data. Machinery to process such data soon followed. This type of accounting, called unit record, maintained each unit record as a separate physical entity, which allowed files to be sorted, merged, split, and printed from without having to copy them. Keypunch and verifier operators transcribed data from documents to cards, and teams of operators moved files of cards from machine to machine—files of thousands, even millions of cards. Experienced operators put together the operational procedures and plugged program panels.

Writing

Most cultures do not spread wealth and power uniformly through society. Hierarchical by nature, most societies concentrate wealth and power at the top and attenuate it all the way down. Communication maintains the hierarchy, which in preliterate societies was limited in time and in distance, with personal memory being used to preserve ideas and commands over time, and drum or whistle languages over distance.

Physical representation overcomes both limitations at once. The clay bullae and tablets of five millennia past combined impressed numbers and pictographic names, and the pictographic writing evolved into the hieroglyphics of Egypt that some scholars argue triggered the Chinese writing method. The hieroglyphs of Egypt were written by scribes and used by priests, and mandarins wrote and used the logograms of China. The hieroglyphs of Egypt evolved into widely used alphabetic systems of writing more directly based on lower-level speech components, which made them more effective for the administrative control and propaganda needed to sustain and expand hierarchical societies.

Perhaps because writing provided a more significant tool for social control than reckoning or accounting, its technology received more attention. Scribes used papyrus, vellum, parchment, and other bases for writing on as individual message sheets and scrolls and later as bound books. The expense of keeping scribes to transcribe important books, often imperfectly, led to the development of printing technology, first with the hand press, starting about five centuries ago, then with the machine press about two centuries ago (Philip Gaskell, *A New Introduction to Bibliography*, Oak Knoll Press, 2000).

In the early stages of printing, the industry replaced scribes with skilled workers like typecasters, compositors, pressmen, and binders—and with professionals like master printers and punch cutters. The later stages of printing involved different machines and more trades, as well as professionals like authors and illustrators.

INTERLUDE

This early history shows that writing developed from accounting, which had developed from reckoning. The more direct use of writing for social control is arguably why its technology advanced sooner and faster than the technology of accounting and reckoning.

Increasing cheapness of printing led eventually to wider literacy and a greater variety of publications. Cheaper printing also led to books being used outside religious and other administrative circles and to mass production of impermanent products like pamphlets and newspapers. Widespread use of printing by press, duplicator, copier, and personal printer or typewriter led to the characteristic printing trades and professions becoming subsumed in the activities for which the printing was used. Such craftsmen, while still there, were pushed into the background.

The development of modern computing was like the earlier development of printing and publishing, but it focused on reckoning and accounting. It might well be possible to predict the computing profession's future from what happened to the people dependent on printing. One difference is that both reckoners and accountants adopted the electronic computer at about the same time.

THE ELECTRONIC COMPUTER

Reckoners, the accumulators of knowledge, needed automatic computing machinery because their modeling of accumulated complexity and manual simulation became too slow and fallible. Analog computers helped for a while, but they lacked the required accuracy. Accountants, the managers of property, needed similar machinery because the traditional punched card methods were slow and labor-intensive. Arithmetic was not the problem, expense was.

Early scientific computers typically used binary arithmetic, and they were used for "number crunching," with the results stored on paper and magnetic tape. Early commercial computers used decimal arithmetic for automatic data processing, spawning common initialisms such as ADP, EDP, and, simply, DP. Data arrived on punched cards and left as output to a high-speed printer. Master files resided for a while on magnetic tape, although the soon-to-be-developed magnetic discs would allow direct access to within those master files, particularly for inquiry.

Reckoners operated their own machines and wrote their own programs. Because their computers were expensive, time-sharing systems were soon developed so that users could reckon on their computer simultaneously. Because programming required some special skills, accountants hired programmers who worked apart from the operators. Management promoted experienced programmers to become system analysts, who specified needed programs rather than coding them.

Cheap personal computers and networking changed the world dramatically.

Even though increased production led to computers with both binary and decimal arithmetic, scientific and commercial computing remained distinct. Technical computing usually involved scientists and engineers working closely with their computing departments. In the commercial world, the DP department became a highly political entity within an organization, an entity that fought for power by undertaking only large projects and dictating to end users the capabilities they were to have.

Because their prospective users built the first electronic computers, courses in computing at universities usually started in technical departments such as physics or electrical engineering—and stayed there. As commercial computing evolved, commerce and management schools realized their students needed training in computing and set up computing departments with their redundancy hidden under names like Information Systems.

The dichotomy also appeared in professional computing organizations. In countries with a single computer society, control of the society typically oscillated between the scientists and technologists, who saw themselves as naturally in charge of the profession, and the commercial practitioners, who saw the academics as out of touch with reality.

The availability of cheap personal computers and networking has changed the world dramatically, and not just within the computing profession. Machines like typewriters and vocations like typing and stenography have almost disappeared. DP (now IT) departments still exist in large organizations and still focus on large projects that typically fail to meet their original objectives, but small organizations now get along without them.

However, professional computing courses and organizations are withering. With cheap computers and networking available, people see them as part of everyday life, both at work and in the home. What need is there, then, for computing professionals?

The education and computing sectors could work together to reconfigure the way computing is used and to provide more benefit to society from digital technology. This would also reconfigure the computing profession and give it a more productive future. My essay of last January outlines one possible approach. But whatever approach we take, the computing profession must act soon and vigorously to avoid the old printing profession's fate.

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The History of the Computing Profession

Neville Holmes, University of Tasmania

With cheap computers and networking available, who needs computing professionals?

My January 2007 essay ("The Computing Profession and Higher Education," pp. 116, 114-115) prompted an invitation for me to lead a discussion about the computing profession at an IEEE/IEAust evening meeting in Brisbane. Asked also to speak at a lunchtime meeting at the University of Queensland, I put together a presentation titled "The Early Development of the Computing Profession" designed to attract students to the evening meeting.

In one sense, the lunchtime gathering proved very successful, filling the meeting room, prompting attendees to ask many questions and to have me go on long past the lunch hour's end. In another sense, however, my presentation failed completely because no students attended the evening meeting. The reason became clear in hindsight: I had overloaded the presentation with URLs for early machinery, mainly machinery I had used and could explain to questioners (see http://eprints.utas.edu.au/1301). Thus, I spent most of the time explaining what used to be done and relatively little time considering what kind of people did that work.

The pity of this is that the early computing people were far more interesting than the machinery. Further, the people I did talk about made their contributions relatively recently. With this essay, I seek to redress the balance and, more importantly, to provoke discussion of the profession's future.

EARLY HISTORY

Computation, according to the usual dictionary definitions, addresses the manipulation of numeric values. My *Oxford English Dictionary* defines *computing* primarily as the "act of calculation or counting." The term has developed a much wider meaning today, with few digital computer applications focusing on arithmetic. This has occurred because different formal social activities developed with distinct human vocations, all of which modern digital technology supports at various stages and to various degrees.

Human society is based on language, the first digital technology, one that started long ago and originally involved only speech and gesture. The use of tools in digital technology developed relatively early in three areas: reckoning and mathematics, accounting and bookkeeping, and writing and communication.

Reckoning

Numbers formed an early part of human culture and language, as suggested by their rich use in various forms in preliterate societies (Marcia Ascher, *Ethnomathematics*, Wadsworth, 1991).

The most significant use of numbers was and remains in understanding how things work. Predicting the moon's phases once played an important role in scheduling nocturnal activities. An eagle bone discovered in France and measured to be 13,000 years old is notched in a manner strongly suggesting a recording of the lunar month's days (David Ewing Duncan, *The Calendar*, Fourth Estate, 1998). Other European artifacts, two or three times older, show similar if less strongly suggestive markings.

People required more formal calendars when agriculture developed. Many of these, based on lunar months, were numerically complex. Almost six millennia ago, the Egyptians set up a solar calendar of 365 days that they used for four millennia. Although halfway through this period astronomers calculated the need for a leap day every fourth year, the priestly bureaucracy prevented this reform.

The socially significant time of day is solar. Sundials are simple and useful, providing the sun is out, but people also developed other devices for measuring time. The most significant development—the escapement clock—provided perhaps the first analog-to-digital conversion device. A Chinese astronomical clock used an hydraulic escapement a thousand years ago, but the European adoption three centuries later of an oscillatory drive for the escapement was highly significant:

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